In the circuit of FIG. 6 three sensors **108, 110** and **112** are located adjacent to the rows of contacts **102, 104** and **106**, respectively. Whenever the disc **100** rotates and one of the contacts of one of the three rows comes under a sensor, a voltage is delivered over one of the lines **114, 116** or **118**, leading to circuitry located at the computer. The contacts on the three rows **102, 104** and **106** are located so that only one contact is under a sensor at any given time.

The lines **114, 116**, and **118** trail behind the position indicator control and lead to flip-flop **120**, OR gate **122** and AND gates **124** and **126**, as shown. The outputs of the two AND gates **124** and **126** lead to counter **128** to cause it to count up or down. The counter **128** has numerous output lines over which it continuously transmits signals indicating in a digital manner, the position of the position indicator control.

When the disc **100** of FIG. 6 rotates and a contact of row **104** comes under readying sensor **110**, a signal is transmitted over line **116** to set the RS flip-flop **120**. If the disc is rotating in a forward or clockwise direction the next contact of the three rows to come under a sensor is a contact of up row **102**. When a contact **102** touches sensor **108**, a signal is transmitted over up line **114** to AND gate **124**. Inasmuch as the flip-flop **120** has been set, a voltage is being received at input **130** of gate **124**, and the additional signal at input **132** of gate **124** causes it to generate a pulse. The pulse from gate **124** enters counter **128** at its up input, causing the counter to count up by one digit. The signal over up line **114** also enters OR gate **122** which leads to delay line **124** which, in turn, leads to the reset input of flip-flop **120**. A delay of delay line **124** is very short so that flip-flop **120** is reset an instant after an up pulse is registered by the counter.

If the disc **100** continues to turn clockwise after an up pulse is registered, then a contact of row **106** comes under down sensor **112** and causes it to deliver a signal over down line **118** to the AND gate **126**. The AND gate **126** will not deliver a pulse because its input **134** from the flip-flop **120** has no voltage on it, due to the fact that the flip-flop **120** has been reset. Only after another signal is transmitted over line **116** to again set the flip-flop **120**, will a pulse from up line **114** cause the registation of another up count. Down counting occurs in a similar manner when the disc **100** turns in a counter clockwise direction.

The circuit of FIG. 6 requires only four leads between the computer and the position indicator control. The four leads are the lines **114, 116, 118**, and an additional line (not shown) for connection to a voltage source to provide pulses that flow through the sensors to the other three lines.

FIG. 7 illustrates another position readout means of the incremental encoder type, similar to that of FIG. 6. The circuit of FIG. 7 utilizes a simpler encoding disc and one fewer lead, although it involves more complex electronics. In the circuit of FIG. 7, a disc **140** whose axis is connected to a position wheel such as the X position wheel is provided which has a track **142** having spaced conductive segments. A control contact **146** and stepping contact **148** are disposed over the track to make contact with the conductive segments thereof. The contacts are arranged for contacting the segments at angular positions of the disc which overlap. A lead (not shown) connected to the disc **140** conducts currents to the segments of the two tracks.

The contact **146** is connected to a Schmidt trigger circuit **150** which provides currents to two of four AND gates **152, 154, 156** and **158**, at a time. The other contact **148** carries current to a resolver **160** of the Schmidt trigger, on-off type, which provides signals with sharp, standard on-off wavefronts. The output of the resolver is delivered to a differentiator **162** which delivers sharp pulses to an inverter chopper **164** and a normal chopper **166**. The outputs of each chopper are delivered to two of the AND gates. The outputs of two of the AND gates deliver pulses to the up input port **168** of an up/down counter **170** while the outputs of two other AND gates are delivered to the down input port **172** of the counter. The counter **170** continuously delivers digital output signals defining the position of disc **140**.

While the position indicator control can be used merely to cause a change in cursor position, and other means such as a typewriter can be used for adding to the pattern, the indicator control can be used in other ways. For example, the position indicator control can be placed on a drawing to be displayed on the CRT, and then the indicator control can be moved to trace the lines of the drawing with the computer causing corresponding lines to be displayed on the CRT. For such uses, the wheels and electrical signal generators of the indicator control should cause cursor movements which very closely correspond to indicator control housing movements.

The particular mechanical construction shown in FIGS. 2 and 3 are especially well adapted for maintaining accuracy of output and ease of use. The use of only three points of contact, comprising the two wheels and the ball bearing support, help to assure that both wheels will constantly remain in firm contact with the surface on which the position indicator control rests. The location of the various buttons for indicating areas of the display to be operated on, or for other purposes, on the indicator which is moved by the hand allows a human operator to maintain control over both position of changes and the type of changes on the display with only one hand. The use of an indicator control which rests firmly on a surface enables the operator to accurately maintain position with a minimum of muscle effort, since the indicator control remains stationary unless some force is applied to it. The use of relatively large position wheels having appreciable, even if small, moments of inertia, reduces jittering of the indicator control and promotes smooth movement which is helpful in accurate positioning where the displayed characters are small or where accurate tracing of a pattern is required.

While particular embodiments of the invention have been illustrated and described, it should be understood that many modifications and variations may be resorted to by those skilled in the art, and the scope of the invention is limited only by a just interpretation of the following claims.

I claim:

**1.** In a display system controlled by a computer whereby the display is alterable in accordance with signals delivered to said computer which indicate positions on said display and changes desired to be made therein, the improvement in a position indicating control apparatus which is movable over a surface to provide position indications corresponding to positions on said display comprising:

a housing;

a first position wheel rotatably mounted on said housing and having a rim portion extending past the boundaries defined by said housing for supporting said housing on said surface;

a second position wheel rotatably mounted on said housing with its axis of rotation oriented perpendicular to the axis of said first wheel, said second position wheel having a rim portion extending past said housing for supporting said housing on said surface;

transducer means connected to each of said first and second wheels, for generating digital position indicating signals indicating the degree of rotation of said wheels; and

flexible conductor means for connecting said transducer means to said computer, for conducting said position indicating signals to said computer while enabling unrestrained movement of said housing relative to said computer.